Physical Science Informatics: Providing Open Science Access to Microheater Array Boiling Experiment Data

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Objective

- Physical Science Informatics system implements Office of Science and Technology Policy (OSTP) memorandum, Feb. 22, 2013 entitled “Increasing Access to the Results of Federally Funded Scientific Research” by enabling multiple researchers simultaneous, open-science, access to synergistically build upon ISS data.

- Maximize the value of this important data by mass disseminating past, current, and future ISS physical science data to the broad science, engineering, and STEM community including industry, academia, and government.

- Accelerate from ideas to state-of-the-art of physical sciences research and to products, publications, and patents.
Open Science Examples

- Data science: A new emerging field with the goal of “extracting meaning from data and creating data products”. [definition courtesy of Wikipedia.]
- Has emerged as a new field to glean knowledge and new understanding from the large volume and diversity of data being published or available and accessible on the internet.

**Examples:**
- Tracking Hurricane Sandy: Barometric pressure data from local weather stations, available on-line, accurately track the storm’s path.
- Google researchers discovered close relationship between searches on flu-related topics and spread of influenza. Published in Nature Vol 457, 19 February 2009, doi:10.1038/nature07634
- Human behavior researchers using Google n-gram database (data from Project Gutenberg) found evidence for distinct historical periods of positive and negative moods in 20th century books.

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Open Science Campaign Platform*

1. Science Definition Team to plan and oversee scientific requirements
2. NASA develops CONOPS, performs all associated science activities, and manages payload integration
3. ISS flight experiment operations
4. Digital Data downlink and sample return for analysis
5. Physical Science Informatics System

Timeline

- BXF was delivered to the ISS aboard ULF-5, which launched in February, 2011.
- BXF was installed on Tuesday March, 22.
- Week 1: Hardware setup and checkout, MABE and NPBX heater characterizations
- Weeks 2 and Week 3: MABE and NPBX test points.
- On Monday, April 11, anomalous pressure readings tripped the BXF safety circuit, halting operations. Attempts to restart/reset/recycle BXF did not correct these readings and BXF was shut down.
- By this point MABE completed 260 of 540 tests. NPBX completed less than half of planned tests.
- On-orbit troubleshooting was performed via ground-control.
- Limited NPBX operations could still be performed without failed power bus.
- BXF was removed from MSG and returned on ULF-7.

The Boiling eXperiment Facility was installed in the Microgravity Science Glovebox (MSG):

- Two distinct experiments:
  - Micro-heater Array Boiling Experiment (MABE) PI: Prof. Jungho Kim, University of Maryland
  - Nucleate Pool Boiling Experiment (NPBX) PI: Prof. Vijay K. Dhir, University of California at Los Angeles
- Normal-perfluorohexane, C₆F₁₄, as the test fluid
- Operated between pressures of 60 to 244 kPa and temperatures of 35 to 60 °C.
- Measured Pressure and bulk fluid temperature.
- Acquired standard rate video.
Determined the local boiling heat transfer mechanisms in microgravity for nucleate and transition boiling and the critical heat flux by examining the position of the liquid and vapor adjacent to the heater.

MABE was incorporated two 96-element microheater arrays, to measure localized heat fluxes while operating at a constant temperature.

- 2.7 by 2.7 mm (not acquired)
- 7.0 by 7.0 mm
Physical Science Informatics Platform

- **Accessibility** - Available to the national and international user community, using popular devices such as iPhone, iPad, Android, PC, Mac, Linux with web-based Google like search capability.

- **Collaboration** - Allow for data to data links, and provide researchers the ability to comment about the data in either private or public discussions.

- **Generate metric and usage reports** - Track usage for NASA managers and the science definition teams in planning, gap analysis, data ranking, student (undergraduate and graduate) impact, and for future system improvement.

- **Security and Access Controls** - Access controls will protect the data according to the data agreement and to support security controls for SBU, International Traffic in Arms Regulations (ITAR), company proprietary, or Export Administration Regulations (EAR), data system will need to be on a NASA moderate security plan.

- **Export tools** are available to through a set of web services so that a variety of research tools can be used to analyze the data.
Requesting Access

Website access requires a USERID and Login.
Submit form at http://psi.nasa.gov/Request.aspx:
- First, Middle and Last Name
- Phone
- Email
- Organization
- Address
- City
- Country
- State
- Postal Code
- Citizenship
- Company
- Manager’s Information
  - First and Last Name
  - Phone
  - Email
- Projects (NASA tracks who uses the database and what they use it for. Ultimately, this is one metric used to warrant continuation of this resource)
- Justification

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Welcome to ISS Physical Science Informatics System

Overview:
NASA's Physical Sciences Research Program, along with its predecessors, has conducted significant fundamental and applied research, which has led to improved space systems and produced new products offering benefits on Earth. NASA's experiments in the various disciplines of physical science, reveal how physical systems respond to the near absence of gravity. They also reveal how other forces that on Earth are small compared to gravity, can dominate system behavior in space. The International Space Station (ISS) is an orbiting laboratory that provides an ideal facility for conducting long-duration experiments in the near absence of gravity and allows continuous and interactive research similar to Earth-based laboratories. This enables scientists to pursue innovations and discoveries not currently achievable by other means. NASA's Physical Sciences Research Program also benefits from collaborations with several of the ISS International partners—Europe, Russia, Japan, and Canada—and foreign governments with space programs, such as France, Germany, and Italy. The scale of this research enterprise promises new possibilities in the physical sciences, some of which are already being realized both in the form of innovations for space exploration and in new ways to improve the quality of life on Earth.

Research Areas:
Biophysics: biological macromolecules, biofluids, biomaterials, and biological physics
Combustion Science: spacecraft fire safety, droplets, gaseous - premixed and non-premixed, solid fuels, and supercritical reagents
Complex Fluids: colloids, liquid crystals, foams, non-Newtonian fluids, and granular flows
Fluid Physics: two-phase flow, phase separation, boiling, condensation and capillary and interfacial phenomena
Fundamental Physics: space optical atomic clocks, quantum test of equivalence principle, cold atom physics, critical point phenomena, and dusty plasmas
Materials Science: crystal growth, metal and alloys, electronic materials, glass and ceramics, and polymers

Implementing Centers:
NASA's Physical Sciences Research Program is carried out at the Glenn Research Center (GRC), Jet Propulsion Laboratory (JPL) and Marshall Space Flight Center (MSFC).

Heritage:
Space Life and Physical Sciences Division 2012 - present
ISS Research Project 2004-2012
Advanced Life Support - Life Support and Habitation Program 2004-2006
Office of Biological and Physical Research Program 1998-2004
Microgravity Research Program 1994-1999
General Search, searches all records and attached files
Experiment Record

- Data mine with multiple views to understand data connections
- Generate reports to compare data or identify data gaps
- Export reports to excel or PDF
- Inside NASA Firewall Only to edit/update/add new records

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Investigation Overview Tab

**Research Objectives:** Boiling efficiently removes large amounts of heat by generating vapor from liquid; this process is currently being used in many power plants to generate electricity. An upper limit, called the critical heat flux, exists where the heater is covered with so much vapor that liquid supply to the heater begins to decrease, potentially destroying the heater. Microheater Array Boiling Experiment (MABE) 4 ...

**Research Overview:** Microheater Array Boiling Experiment (MABE) is one of two investigations scheduled to operate in the Boiling eXperiment Facility (B XF). The other investigation is Nucleate Pool Boiling Experiment (NPBX).

Understanding of microgravity effects on boiling mechanisms is critical to the proper design of heat removal equipment for use in space-based applications.

**Space Applications:** In microgravity, a bubble can cover an entire heater array instead of just a small area, resulting in burnout of components if local hot spots are present. The increased spatial resolution of these measurements will enable the extent of the dry spot to be measured along with the heat transfer from the liquid surrounding the dry spot. This technique can be applied to other areas including spray coolage.

**Earth Applications:** The proposed research has shown that transient conduction is the dominant heat transfer mechanism in boiling of refrigerants-like fluids. This research will provide insight into creating more efficient cooling systems on Earth.

**Other Information:** MABE Other Information
Scientific Data and Information

Where the Video and Data will be Stored

Experiment Definition

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Selected Drawings & Engineering Reports and Test Data Relevant to Analysis of Scientific Data.

Other Experiments Operating during Same time frame.

ISS Facility Used
Engineering Data

Note:
- Units are typically in SAE (inches, pounds, etc.)
- BXF had several hundred drawings, analyses, reports, etc.
- Only those files that are needed for interpretation of science data (for example position of sensors) have been entered.
- Other files can be requested.
- Some files will not be entered; for example, drawings related to hardening of high-speed camera because of proprietary nature.
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<th>Drawing No.</th>
<th>Title</th>
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<td>Overall Assembly</td>
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<td>TEST CHAMBER TOP PLATE ASSEMBLY</td>
<td>Position of Pressure Sensor Taps</td>
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<td>COOLING CHAMBER ASSEMBLY</td>
<td>Positioning of Heater Arrays and Backside Cooling</td>
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<td>MABE HEATER BONDING ASSEMBLY</td>
<td>Positioning of Heater Arrays</td>
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<td>Bulk Fluid Heater</td>
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<td>Test Chamber</td>
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<td>Backside Cooling Chamber</td>
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<td>Annular Tube for Bulk Fluid Heater</td>
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<td>BXF FLUIDS SCHEMATIC FLIGHT SYSTEM</td>
<td>Fluid System Schematic</td>
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<td>BXF Critical Design Review Charts</td>
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Some reports are on-line and publicly available, however, others may require a subscription to the appropriate journal.
Plans

- PSI Database becomes publicly available during October 2014.
- Limited Data for MABE is on-line.
  - Drawings
  - Reports
  - Links to publications
  - “Raw” Excel Spreadsheets for MABE Test Cases
  - Downlinked Video
- Data to be posted:
  - Processed Local Heat Transfer Coefficient
  - Synchronized Video Data (Side View and Through Array)
Comments, Suggestions

MABE Specific:
  Types of Data to see
  Format of Data
PSI Database
  Presentation Format
Comments, Suggestions

- Who to contact:
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